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FGT-3093
15 April 1964

MATERIAL - ADHESIVE - DYNABOND 132 -
ADDITIONAL TESTING AND DISPOSITION
OF SPECIMENS REMAINING FROM 420°F CREEP TEST (50-2895)

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GENERAL DYNAMICS | FORT WORTH



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Department 6
FWP 1999-9-54

TEST NO. 50-2968

MODEL F-111

REPORT FGT 3093

DATE 28 Feb. 1964

TITLE

MATERIAL - ADHESIVE - DYNABOND 132 -
ADDITIONAL TESTING AND DISPOSITION
OF SPECIMENS REMAINING FROM 420°F CREEP TEST (50-2895)

SUBMITTED UNDER

The tests described in this report were conducted between 8-8-63 and 9-20-63.

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NO. OF PAGES 15

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REVISIONS



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MATERIAL - ADHESIVE - DYNABOND 132 -
ADDITIONAL TESTING AND DISPOSITION
OF SPECIMENS REMAINING FROM 420°F CREEP TEST (50-2895)

PURPOSE:

Sandwich panel structure of various material combinations for use in F-111 high temperature areas are being considered by the Structures and Fuselage Design groups as possible alternates to bonded titanium structure. Material combinations are PH15-7 Mo honeycomb core and skins, glass reinforced plastic (GRP) honeycomb core and skins, and GRP honeycomb core and PH15-7 Mo skins, all bonded with Dynabond 132 adhesive.

The purpose of this test was to determine creep properties of these various materials at 325°F, resistance to environmental conditions, and high temperature beam shear strengths of these panels bonded with Dynabond 132.

SUMMARY:

Specimens were cut from the various material combination sandwich panels bonded with Dynabond 132 and tested as follows:

1. PH15-7Mo-TH1050 Skins and Core; in beams which had previously been subjected to creep tests for 10 hours at 420°F followed by 30 minutes at 490°F., core shear was not developed at 500°F. Ultimate beam loads on this type construction produced core shear failures at 75° and 420°F, but at 500°F adhesive failure was produced.
2. PH15-7 Mo Annealed Core and Skins; these sandwich beams were tested in creep at 325°F for 300 hours, followed by ultimate beam strength tests. The creep test produced a permanent set of 0.065 in. in the beams, and core shear failure was developed in all beams tested at 420° and 500°F.



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3. GRP Skins and Core;

- A. Beams constructed of these materials with core undergoing a pre-cure for 30 mins. in a 350°F air circulated oven, had an average permanent set of 0.060 in. after 300 hours in the 325°F creep test. Ultimate beam strength of these beams developed core shear failures at 325°, 420°, and 500°F.
 - B. Beams constructed of these materials with core undergoing a pre-cure for 1 hour at 500°F in a vacuum of 29.5 in. of mercury had an average permanent set of 0.078 in. after 300 hours in the 325°F creep test. Ultimate beam strength at 500°F produced core shear failures.
4. PH15-7 Mo Annealed Skins and GRP Core (Vacuum pre-cured as in 3.B.); Beams constructed of these materials, had an average permanent set of 0.112 in. after 300 hours in the 325°F creep test. Ultimate beam shear strength tests of these beams produced adhesive failures at 420° and 500°F.

Flatwise tension specimens cut from all four types of panels were exposed to salt spray and humidity for 30 days. No detrimental effects were detectable after these exposures and no salt or moisture penetrated into the interior cells.

MATERIAL - ADHESIVE - DYNABOND 132 -
ADDITIONAL TESTING AND DISPOSITION
OF SPECIMENS REMAINING FROM 420°F CREEP TEST. (50-2895)

OBJECT:

To determine environmental resistance and high temperature strength properties of various material combination sandwich panels, bonded with Dynabond 132.

DESCRIPTION OF MATERIALS:

Materials in Composition of Sandwich Panels:

Adhesive - Dynabond 132 (0.14 lbs/sq ft) Prepared in GD/FW's Materials Lab., 9-1-63

Stainless Steel Skins 0.025 in. thick PH15-7 Mo	Armco Steel Corp. Middletown, Ohio
Stainless Steel Core, Type 3-15 NP PH 15-7 Mo	Honcor Corp. Hawthorne, California
GRP Skins 0.080 in. thick, Conolon 506 (Narmco)	Manufactured in GD/FW Shop
GRP Core, 7.12 lb/cu ft, 3/16 in. cells	Hexcel Products Inc. Berkeley, California
Beams 3 x 15 in., Dynabond 132 Stainless Steel (Core & Skins) PH 15-7 Mo, TH 1050	From Test Request 50-2895

PROCEDURE:

- I. Preparation of Stainless Steel Core and Skins for Bonding:
 - A. Clean skins by brush - scrubbing with methyl ethyl ketone, and allow to air dry.

B. Vapor degrease core and skins in stabilized trichloroethylene for 10 minutes.

C. Immerse skins in nitric acid solution of the following composition for 10 min. at 75°F .

Nitric Acid Solution	
Nitric Acid (70%)	170 Milliliters
MF Acid	59.5 grams
Tap Water	Bring total volume to one liter

D. Immerse skins in tap water until thoroughly rinsed.

E. Immerse skins in a chromic acid solution of the following composition at 140°F for 12 min.

Chromic Acid Solution	
<u>Material</u>	<u>Parts by Weight</u>
Water	30
Sulphuric Acid (66°Be)	10
Sodium Dichromate	4

F. Rinse skins in tap water.

G. Thoroughly rinse skins in a spray of distilled water and dry in an oven maintained at 160°F to 170°F .

II Preparation of GRP Skins and GRP Core for Bonding:

A. GRP skins (FMS-0031 Class III) were manufactured in GD/FW's shop in accordance with FPS-1016.

B. GRP Core;

1. GRP core to be used with stainless steel skins, and one set of GRP skins were vapor degreased for 10 min. in stabilized trichloroethylene, then post cured in a vacuum (29.5 in of Hg) at 500°F for 1 hour.

2. GRP core for remaining GRP skins was vapor degreased as above and post cured for 30 min. in an air circulating oven at 350°F .



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III Bonding Procedure:

- A. Stainless steel and GRP skins;
 - 1. One layer of Dynabond 132 was applied to each stainless steel skin.
 - 2. The peel ply was removed from the GRP skins and one layer of Dynabond 132 was applied to each skin where the peel ply was removed.
- B. The core and skins were mated and panel was placed in a press. One layer of 0.125 in. curable rubber was placed over the sandwich panel for even pressure distribution.
- C. Panels were bonded under 45 psi pressure at $350^{\circ} \pm 2^{\circ}$ F. Warm-up time to 350° F was 25-5 mins.
- D. Bonded panels were post cured in an air circulating oven at $465^{\circ} \pm 5^{\circ}$ F for 1 hour.

IV Creep Test:

- A. Three beams, 3.125 x 15 in. were sawed from each of the four panels, and milled to 3.00 x 15 in.
- B. Ten of these twelve beams were placed in the creep machine as per Fig. 4.
- C. The beams were loaded to a core shear stress of 167 psi.
- D. The dial gauges were zeroed and creep machine was heated to $325^{\circ} \pm 2^{\circ}$ F.
- E. When beams reached 325° F, dial gauges were read and recorded.
- F. Dial gauge readings were taken every $\frac{1}{2}$ hour thru 4 hours, then at 12 hour intervals thru 300 hours. (No readings were taken during week-ends.)

G. At the end of the 300 hour period the creep machine was opened and cooled for 30 mins. and then the loads were removed from the beam specimens.

H. When the machine cooled to room temperature, beams were removed and permanent set was measured.

Note: (Permanent set is the highest point of the arc formed when beam is lying concave side down, on a flat surface)

V Ultimate Beam Loads After Completing Creep Tests:

A. One 3 x 15 in. beam of each of the four types was tested for ultimate shear strength at 500°F.

B. One 3 x 15 in. beam of each type was split into two 1½ x 15 in. beams and tested for shear strength at 420°F.

VI Environmental Test:

A. Six flatwise tension specimens were cut from the remaining beam of each type and tested as follows:

1. 2 specimens tested in tension at RT
2. 2 specimens placed in a 20% salt spray at 95°±2°F.
3. 2 specimens placed in 95-100% relative humidity at 120°±5°F.
4. After 30 days, the specimens were removed from salt spray and humidity environments and tested in tension at RT.

RESULTS:

Of the four different systems tested in creep, beams with stainless steel skins and GRP core developed the largest average permanent set, 0.112 in. The other systems developed average permanent sets as follows: steel skins



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and core, 0.065 in., GRP skins and GRP core, 0.060 in., and GRP skins and vacuum post cured GRP core, 0.078 in.

The average permanent set obtained with steel skin systems were higher than expected values. Tensile specimens were cut from the PH15-7 Mo stainless steel annealed skin material. Results were as follows:

Test Temp.	F _{ty}		F _{tu}		% Elongation
	Lbs.	KSI	Lbs.	KSI	
RT	521	37.2	1775	126.7	30%
325°F	435	31.1	1035	73.9	36%

The beams were loaded to apply core shear loads of 167 psi, which produces skin stresses of 30 KSI, therefore, the annealed steel skins were loaded very close to their yield point of 31.1 KSI. For this reason, it is believed that most of the creep in these sandwich panels was due to creep of the skins. Creep - deflection values and creep rates are shown in Table I and Figs. 1-3.

Ultimate shear strength of beams developed core shear failures in most of the beams except those beams constructed of steel skins and GRP core, and all of these failed adhesively. Beam ultimate loads are tabulated in Table II.

Exposure to salt spray and humidity for 30 days had little or no detrimental effect on Dynabond 132 bonded panels, either before or after additional post cure received during creep test of beams from which specimens were cut. Results of flatwise tension specimens, before and after salt spray and humidity exposures, are listed in Table III. There was no penetration of salt or moisture into any interior cells of any specimen.

DISCUSSION:

The creep results listed in Table I are generally consistant with the exception of deflection values given on specimen SS-1. The low values reported on this specimen were due to



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a loose connection that fastens the seat of the dial gauge to the center post of the creep machine.

Ultimate beam shear values reported in Table II, show that Dynabond 132 can develop core shear failure in type 3-15 NP, PH15-7Mo annealed and TH1050 condition stainless steel core at 420°F. At 500°F, core shear failure was developed on the annealed core, but adhesive failure was produced in the beam with stainless steel core heat treated to the TH 1050 condition.

Flatwise tension testing yielded erratic results. Some of the non-reproducibility can be attributed to the relatively large 3/16 in. cells of the GRP and stainless steel core. Some additional non-uniformity was caused by damage to some of the specimens. These specimens were damaged by a thread tap tool that is used to remove excess adhesive from the threads of the flatwise tension test blocks.

Low flatwise tension results were reported on specimens cut from the panel constructed of stainless steel skins and GRP core. This was probably due to the high permanent set developed in this beam during creep rupture tests.

CONCLUSION:

Creep results on Dynabond 132 bonded panels reported herein are not conclusive, because the annealed stainless steel skins were loaded very close to their yield point.

Dynabond 132 bonded sandwich panels will produce core shear failure of annealed and heat treated (condition TH1050) 3-15 NP, PH15-7Mo honeycomb core at 420°F. At 500°F, core shear failure is produced in the annealed core, but not in the heat treated core.

Exposure to salt spray, and humidity for 30 days had no detrimental effect in the bond and no penetration of salt or moisture was found in any of the interior cells of the sandwich panels. (Annealed stainless steel skin-GRP core specimens, exposed to humidity, are an exception to this general conclusion. Previous creep testing of the panel from which the specimens were cut or the cutting technique, may have partially caused the low flatwise tension values.)

TABLE I

CREEP OF SANDWICH PANELS BONDED
WITH DYNABOND 132 AT 325°F

Specimen & <u>Type</u>	Total Defl. From RT thru 300 hrs. @ 325°F, <u>Inches</u>	Defl. @ 325°F, <u>Inches</u>	Permanent Set, <u>Inches</u>
SS-1	0.0263	0.0069	0.065
SS-2	0.0483	0.0134	0.065
SS-3	0.0475	0.0181	0.065
SG-1	0.0878	0.0458	0.135
SG-2	0.0720	0.0465	0.100
SG-3	0.0638	0.0388	0.100
GG-1	0.0545	0.0364	0.055
GG-2	0.0600	0.0415	0.065
GG(V)-3	0.0778	0.0478	0.075
GG(V)-4	0.0837	0.0602	0.080

All beams loaded to a 167 PSI Core Shear Stress.

Note: Data present graphically in Figs. 1, 2, & 3.

KEY:

- SS Annealed PH15-7Mo stainless steel core and skins; core 0.590 in. 3-15 NP, skins 0.025 in.
- SG Same skins as SS; Core GRP, 0.750 in. thick, density 7.2#/ft³, 3/16 in. cells.
- GG GRP core same as SG; GRP Skins 0.080 in., core post cured for 30 min @ 350°F in circulating air oven.
- GG(V) Same as GG except core post cured for 1 hr. @ 500°F under 29.5 in. Hg vacuum.

TABLE II

ULTIMATE SHEAR STRENGTH OF
 3 x 15 IN. AND 1½ x 15 IN. BEAMS
 BONDED WITH DYNABOND 132

Specimen & Type	Size, Inches	Temp., °F	Ult. Load, Lbs.	Core Shear, PSI	Max. Defl., Inches	Type Failure
SSD	1.5 x 15	75	390	216	Not taken	Core Shear
GG	1.5 x 15	325	855	344	0.450	Core Shear
SG	1.5 x 15	325	415	179	0.236	Adhesive
SSD	1.5 x 15	420	310	172	0.202	Adhesive
SSD			370	205	0.276	Core Shear
SS			305	168	0.378	Core Shear
SS			310	171	0.575	Core Shear
GG			770	309	0.422	Core Shear
GG			840	338	0.470	Core Shear
SG			325	140	0.180	Adhesive
SG			340	146	0.260	Adhesive
SSD	3 x 15	500	680	189	0.247	Adhesive
SS			560	154	0.247	Core Shear
GG			730	146	0.210	Core Shear
GG			625	125	0.185	Adhesive
GG(V)			780	156	0.222	Core Shear
GG(V)			725	145	0.208	Core Shear
SG			440	95	0.105	Adhesive

Load Rate 500 lbs./min.

KEY:

- SSD Stainless Steel Core and Skins HT 1050 condition (TR50-2895)
- SS Stainless Steel Core and Skins Annealed Condition
- GG GRP Core and GRP Skins, Core post cured in circulating air oven for 30 min. @ 350°F
- GG(V) GRP Core and GRP Skins, Core post cured in 29.5 in. Hg Vac. for 1 hr. @ 500°F
- SG Stainless Steel Skins (annealed) & GRP Core
Load pads 3/4 in.
Support pads 1/2 in.



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TABLE III

ENVIRONMENTAL TEST
 FLATWISE TENSION STRENGTH OF
 SANDWICH PANELS BONDED WITH DYNABOND 132
 TESTED @ $75^{\circ}\pm 3^{\circ}$ F

Specimen & Type	Condition	Load to Fail Lbs.
SSD	Control	1540
SSD	Control	2860
SSD	Salt Spray	1875
SSD	Salt Spray	2170
SSD	Humidity	1580
SSD	Humidity	2465
SS	Control	890*
SS	Salt Spray	1440
SS	Salt Spray	1500
SS	Humidity	1160
SS	Humidity	45*
GG(V)	Control	860
GG(V)	Control	1010
GG(V)	Salt Spray	1340
GG(V)	Salt Spray	970
GG(V)	Humidity	1020
GG(V)	Humidity	770
SG	Control	465
SG	Control	530
SG	Salt Spray	595
SG	Salt Spray	530
SG	Humidity	320
SG	Humidity	345

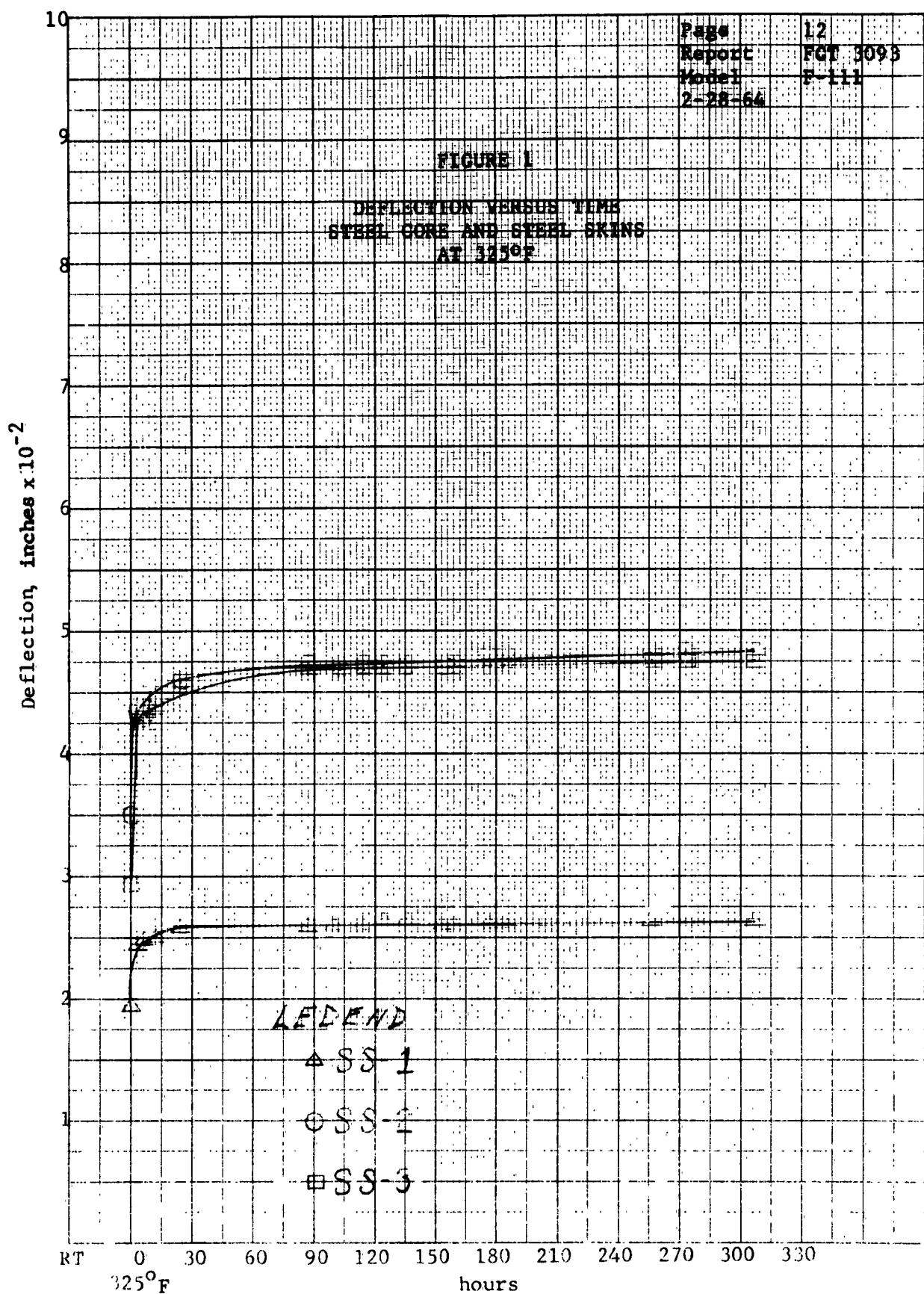
Key	
SSD	Stainless steel core (3-15 NP) and skins TH1050 Cond. (TR-50-2895)
SS	Stainless steel 3-15 NP Core and Skins annealed Cond.
GG(V)	GRP skins and GRP Core, 3/16 in. cell 7.2 lb./cu. ft.
SG	Annealed stainless steel skins and GRP core 3/16 in. cell 7.2 lb/cu.ft.

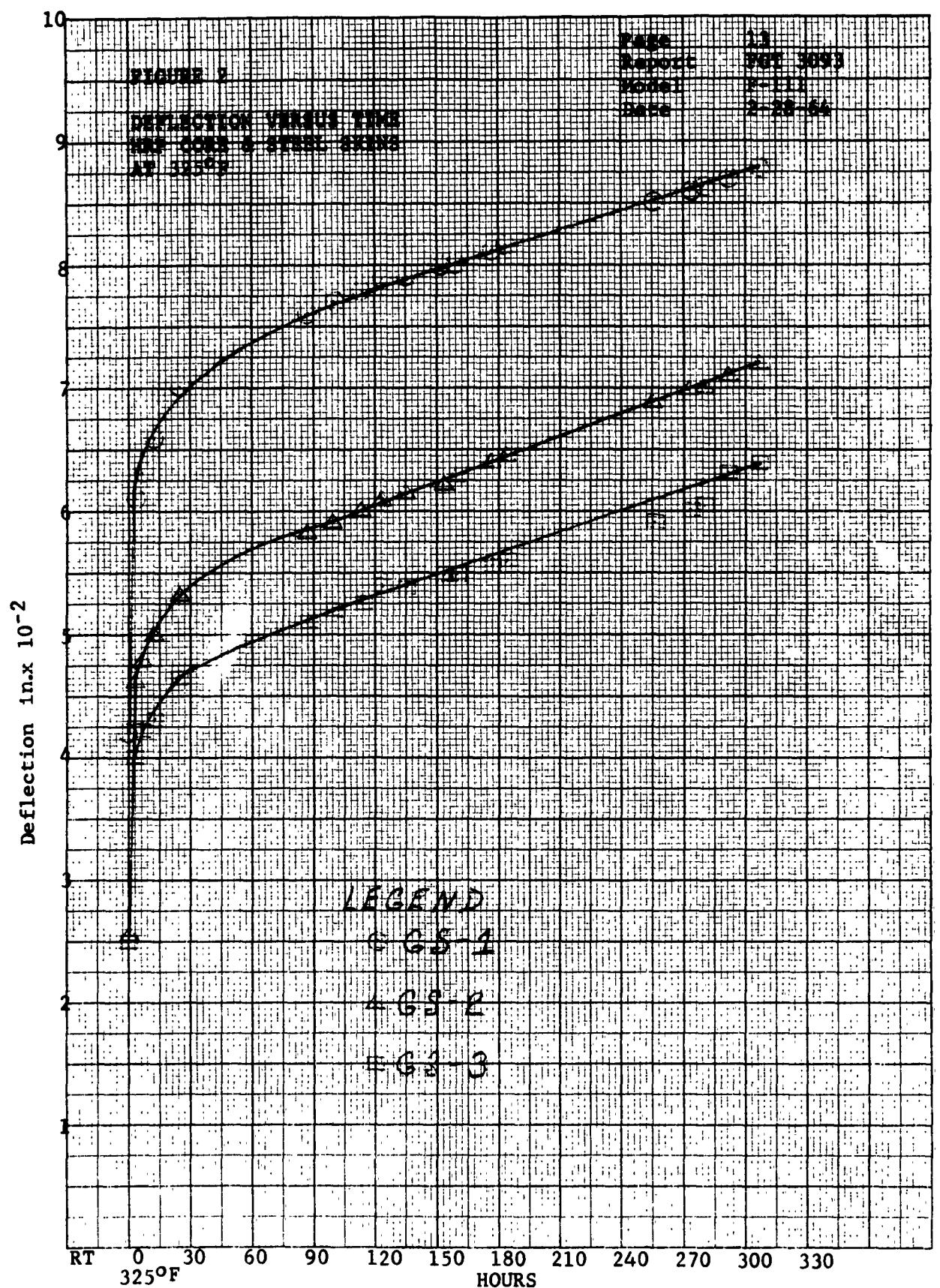
* Specimen damaged with thread tap

Load Rate 4000 lb./min.

Area = Pi or 3.1416 sq. in.

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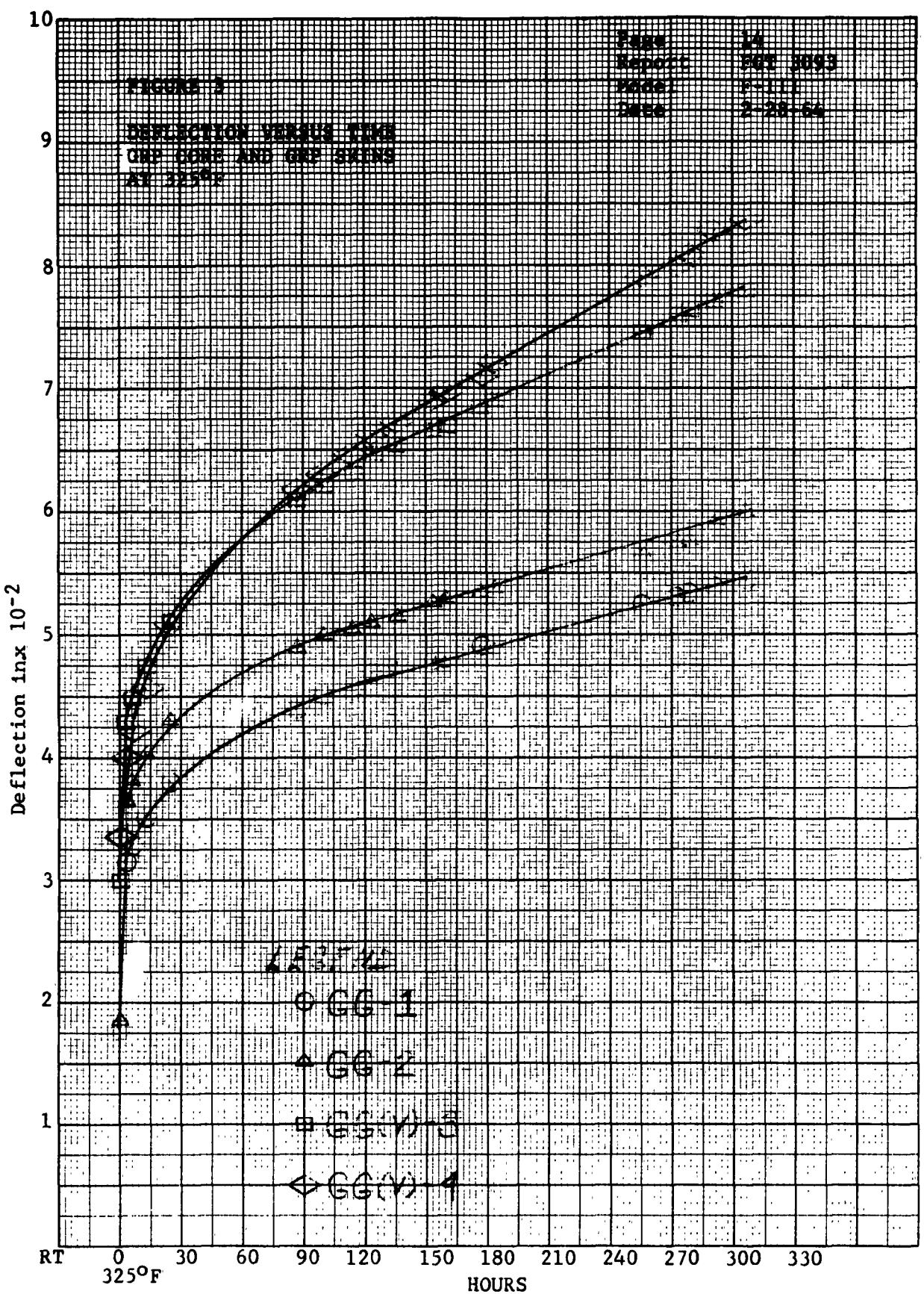
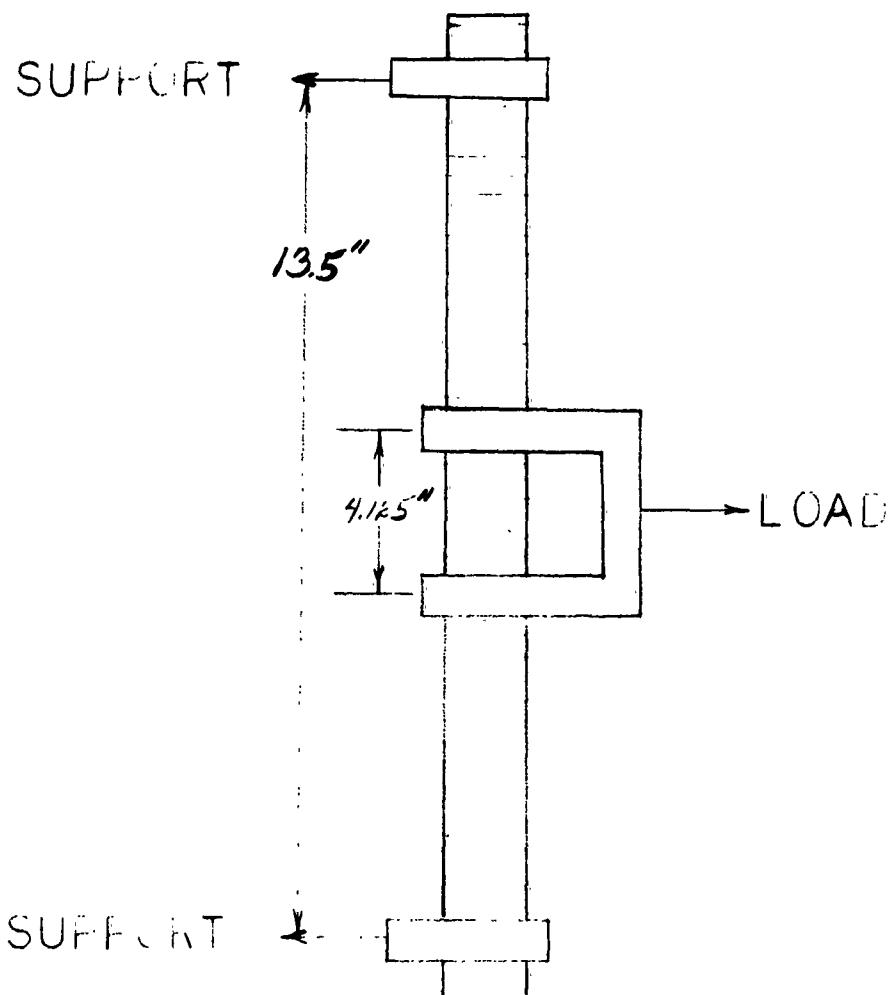


FIGURE 4

CREEP TEST LOADING SYSTEM
ALL SUPPORT AND LOAD PADS
ARE $\frac{1}{2}$ IN.



I, H. L. Miller, attest to the fact that the instrumentation used in obtaining the data for the tests described in this report was at all times calibrated within the specified period established by Standard Engineering practices at GD FW.